

**DESIGN AND IMPLEMENTATION OF A CO₂ FLOOD UTILIZING ADVANCED
RESERVOIR CHARACTERIZATION AND HORIZONTAL INJECTION WELLS IN A
SHALLOW SHELF CARBONATE APPROACHING WATERFLOOD DEPLETION**

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Contractor Name and Address:	Phillips Petroleum Company 4001 Penbrook Street Odessa, Texas 79762
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OBJECTIVE

The first objective is to utilize reservoir characterization and advanced technologies to optimize the design of a carbon dioxide (CO₂) project for the South Cowden Unit (SCU) located in Ector County, Texas. The SCU is a mature, relatively small, shallow shelf carbonate unit nearing waterflood depletion. The second objective is to demonstrate the performance and economic viability of the project in the field. All work this quarter falls within the demonstration project.

SUMMARY OF TECHNICAL PROGRESS

BUDGET PHASE II

TASK V FIELD DEMONSTRATION

Drill Horizontal Injection Wells 6C-25H and 7C-11H

During fourth quarter 1996, three vertical water-alternating gas (WAG) injection wells were drilled along the north boundary with the Emmons Unit. During the drilling of injection Well 6-28W, oil shows were seen in the drilling returns; however, when placed on a production test during late January, the well produced 70% CO₂ cut in the produced gas. This gave us concern that CO₂ was by-passing contact with reservoir rock through the suspected fracture in the toe region of the northwesterly horizontal WAG injection Well 7C-11H. In order to test this hypothesis, a tracer test was attempted between the two wells.

On February 25, 1997, a sulphur hexafluoride (SF₆) tracer test was run on WAG injection Well 7C-11H, with produced gas samples being pulled from Well 6-28W. A trace of tracer gas was found in Well 6-28W within nine (9) hours of injection; however, no additional SF₆ tracer was encountered upon subsequent monitoring. Although first results seemed to confirm that a direct channel exists from the horizontal injector to Well 6-28W, further investigation of the sampling techniques indicate that the sampling may have been tainted, rendering the test results inconclusive.

Drill two vertical WAG injectors along South Cowden Unit boundary - approved under Amendment No. A007 to the Cooperative Agreement for inclusion in Phase II funding

Vertical WAG injection Wells 6-26W and 6-27W were placed on injection during January, 1997. Injection profile surveys were run while on water injection during early February, 1997.

The injection survey on Well 6-26W indicated communication between a water sand at 4344-4355' and casing perforations 4568-4572' and 4578-4582. During the shut-in period, the log indicated that flow from the water sand was entering the wellbore through the perforations in communication at a rate of 35 barrels per day (BPD) and was cross-flowing into the selectively perforated interval 4592-

4726'.

The injection survey also suggested that the selectively perforated intervals below 4700' (4709-4711, 4716-4718, and 4724-4726') were taking approximately 15% of the injection water with evidence of downward channeling. A remedial workover was proposed to squeeze the selectively perforated interval 4709-4726' and the selectively perforated interval 4568-4582' in an effort to limit out-of-zone injection.

The injection log run on Well 6-27W indicated 50-60% of the injection volume was leaving the wellbore through the perforated interval 4746-4748'. The perforated interval 4746-4748' is below the oil-water-contact at approximately -1800' subsea (ss). The injection survey also indicated limited water injection occurring above 4686'. A remedial workover was proposed to squeeze the selectively perforated interval below -1800'ss and to acidize the selectively perforated interval 4552-4671' in an effort to improve the injection profile.

The above-mentioned workovers are planned for second quarter, 1997.

Convert Three wells for Water Injection

During first quarter, 1997, tie-in was accomplished for Well 5-02, which was converted to water injection during 1996 but was shut-in pending injection line tie-in.

Well	-----BEFORE-----			-----AFTER-----
	BOPD	BWPD	MCFPD	
SCU 5-02	12	735	3	Injecting @ 690 BWPD and 720 psig (Mar., 1997)

Reactivate Four Shut-in Wells for Production

During first quarter 1997, four temporarily abandoned wells were reactivated:

	-----AFTER-----			
	BOPD	BWPD	MCFPD	
SCU 2-20	0	250	0	March, 1997
SCU 6-19	0	412	0	March, 1997
SCU 8-13	0	202	0	March, 1997
SCU 7-10	1	183	17	February, 1997

Workover or Recondition Existing Wells

During first quarter 1997, additional perforations were added to Well 6-23. The well was then acidized:

Well	-----BEFORE-----			-----AFTER-----			Comments
	BOPD	BWPD	MCFD	BOPD	BWPD	MCFD	
SCU 6-23	1	0	48	1	249	1	March 1997

Purchase CO₂ and Operation of Recycle Compression Facilities

The CO₂ recycle compression facilities were in operation throughout first quarter.

The total volumes injected in all four injection wells for the fourth quarter were:

GAS INJECTION - MCF

	Jan 97	Feb 97	Mar 97
Monthly	231,358	211,152	239,662
Daily Average	7,463	7,541	7,731
Cumulative	1,353,515	1,564,667	1,804,329

Unit Production

No tertiary response was anticipated until mid-1997. However, oil production has increased approximately 70 BOPD in the near vicinity of the horizontal injection wells from production Wells 6-17, 6-22, 6-24, 7-01 and 7-08. A summary of quarterly average production and injection follows:

Qtr	-----PRODUCTION-----			-----INJECTION-----	
	BOPD	BWPD	MCFD	BWIPD	MSCFPD CO ₂
1st 1996	375	3861	88	4520	0
2nd 1996	356	3526	89	4208	0
3rd 1996	337	4301	91	4144	3623
4th 1996	375	4907	105	4900	8674
1st 1997	442	5837	71	5837	7589

TASK VI TECHNOLOGY TRANSFER

SPE Paper 37470, "The Evaluation of Two Different Methods of Obtaining Injection Profiles in CO₂ WAG Horizontal Injection Wells," written by Kimberly B. Dollens, Burl W. Wylie, James C. Shoumaker, Orjan Johannessen, and Phil Rice, was presented by Ms. Dollens at the 1997 SPE Production Operations Symposium, March 9-11, 1997, in Oklahoma City, Oklahoma.